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On the Impact of the Equator Principles Compliance: Supporting the Decision Making in Projects

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The Equator Principles (EP) are international guidelines for project finance; they target socially and environmentally responsible projects related to large infrastructures and industrial plants, such as energy plants, oil refineries, mines, transports, and telecommunications infrastructures. The aim of this work is the set-up of a methodology for the assessment of Greenhouse Gases (GHG) emissions, that can support the decision-making process of an EPC Company when evaluating different technological alternatives, to select the best available, economically profitable, and environmentally sustainable option, in line with the application of the EP. The assessment of the GHG emissions has gained importance with the issue of latest EP’s version (Equator Principles IV, in force since 2021) that require to perform a Climate Change Risk Assessment associated to Projects. The methodology has been applied, as part of an Energy Efficiency Project, to two different units of an existing Propane Dehydrogenation (PDH) Plant built and set into operation by Tecnimont S.p.A. in the last decade: the steam boiler system and the main compressors (reactor effluent compressors). The methodology for GHG accounting has been applied both to the technical solutions currently implemented in the plant (‘base’ cases) and hypothetical ‘alternative’ technical solutions, with the final goal to assess efficiency and effectiveness of the measures that can be taken to reduce the emissions. For each ‘base case' and its corresponding ‘alternative solution’ a cost estimate has been performed too. The results provide useful information both in terms of carbon footprint and the costs related to the application of the Equator Principles, even in Projects in which their application is not mandatory.

1. Introduction

The Equator Principles (EP) are international guidelines for project finance; they target socially and environmentally responsible projects related to large infrastructures and industrial plants, such as energy plants, oil refineries, mines, transports, and telecommunications infrastructures (Equator Principles, 2020). A project is defined by the EP as: “a development in any sector at an identified location. It includes an expansion or upgrade of an existing operation”. The EP are adopted by financial institutions on voluntary basis. The adopters are together referred as Equator Principles Financial Institutions (EPFIs).
The concept of project finance as a method of funding large infrastructure and industrial assets is of primary relevance. The financing is based solely on predictable and ideally stable cash flows from operations. Since risk is such an important factor in calculating cash flows, risk management plays a critical role in the structuring of projects.
In terms of environmental and social risk the compliance with the EP guarantees the respect of internationally recognised practices, such as the International Finance Corporation (IFC) Performance Standards, the United Nations Guiding Principles (UNGPs) on Business and Human Rights and the Task force on Climate-related Financial Disclosure (TCFD) Recommendations.

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The latest version of the EP (EPIV) requires a Climate Change Risk Assessment. The climate change risk can be defined as the whole of the physical risk and transition risk, which are respectively defined as: the erosion of the value of financial assets due to the increasing severity and frequency of climate-change related extreme weather events, as well as more gradual changes in climate; and the ability of a project to adjust towards a low-carbon economy. The assessment and management of climate change risk of a project, achieved by the EP adoption, would entail easier or better access to capital by increasing investors' and lenders' confidence in the Project (TCFD, 2021).

2. GHG accounting methodology

One of the main parameters used to assess the environmental impact of the Project is the accounting of the greenhouse gases (GHGs) emissions.

2.1 International guidelines for GHG accounting: GHG Protocol

The Greenhouse Gas Protocol (WRI and WBCSD, 2004) is the most widely used international accounting tool. The GHG Protocol standards on "corporate accounting" define how organizations should report the GHG emissions associated with their operations. Specifically, the emissions generated inside a facility owned by a Company are divided into "Scopes". Scope 1 are direct GHG emissions occurring from sources that are owned or controlled by the Company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc., and emissions from chemical production in owned or controlled process equipment. Scope 2 are indirect GHG emissions associated with the generation of the electricity that is purchased by the Company and consumed within the boundaries of the facility. Scope 2 emissions are assumed to occur at the facility where electricity is consumed. The overall annual emissions of a facility (sum of Scope 1 and Scope 2 emissions) represent the facility Carbon Footprint. Assessment is required by EP for all projects, in all locations, when combined Scope 1 and Scope 2 emissions are expected to be more than 100'000 tons of CO_2 equivalent annually (Equator Principles, 2020).

2.2 Calculation methodology

The calculation of a carbon footprint involves the following equation, based on IPCC Guidelines (2006):

$$\text{Carbon footprint emissions} = \text{Activity data} \cdot \text{Emissions factor} \cdot \text{Global warming potential} \quad (1)$$

Activity data is a quantitative measure of a level of activity that results in GHG emissions, e.g., the combustion of fuel (coal, diesel etc.) or absorbed electrical energy.
Emission factors used for calculating direct and indirect emissions, allow to convert activity data into GHG emissions data and are expressed in the form of a quantity of a given GHG emitted per unit of energy (t GHG/GJ), fuel (t GHG/t fuel) or a similar measure (kg CO_2e/kWh). Emissions factors are reported in databases, such as the one from the US Environmental Protection Agency (EPA).
The Global Warming Potential (GWP) of a GHG indicates the amount of warming caused by the emitted gas over a given period (typically, 100 years). These values are a measure to compare the strength of greenhouse effect of different emitted gases relative to carbon dioxide. For example, the global warming caused by 1 kg of methane is 28 times the warming caused by the same amount of CO_2 in each period of 100 years. For such reasons, GHG can be expressed in CO_2 'equivalent' (CO_2e), to consider the role of different greenhouse gases by using the same unit of measurement.

Table 1: GWP values from IPCC fifth assessment report, 2014 (AR5)

Greenhouse gas	Global warming potential (GWP)
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous oxide (N_2O)	265

In practice, the calculation of Scope 1 emissions requires to know the characteristics of the fuels that are burnt inside the facility since, for each fuel, it is necessary to assess the amount and the nature of the GHG that are generated by the combustion. The calculation of Scope 2 emissions is straightforward and is obtained by multiplying the value of the electrical energy (MWh) consumed on a yearly basis within the facility by the electricity emission factor.

This last is highly dependent on the geographic location of the plant, since it results from the fuels mix used for power generation in a specific country or region. The emission factors of electricity may vary greatly worldwide, and change the carbon footprint, as better explained fin the discussion of the results of an alternative design solution presented in this paper (para 3.2). For the present study, related to a plant located in Russia, the corresponding emission factor, taken from literature (EBRD, 2010), is equal to 0.893 tCO_2/MWh.
The methodology described above allows to assess the plant Carbon Footprint once the overall inventory of fuels burnt and electricity consumed on a yearly basis are known. To assess the validity of any alternative design solution with respect to its corresponding solution ('Base' case) already implemented in the plant, it is necessary to assess the share of the plant Carbon Footprint associated to each technical solution. To do this, the plant has been subdivided into different portions. Then, starting from the plant energy, heat and mass overall balances, the amounts of fuels and electrical energy required for one-year operation of each portion of the plant have been computed. These amounts have been converted into an equivalent amount of GHG emissions, by applying the rules set-up in the GHG Protocol. In this way it is possible to associate to each portion of the plant its share of the overall GHG emissions.

3. Case Studies

The abovementioned methodology has been successfully applied in the frame of a Project aiming at improving the energy efficiency of an existing Propane Dehydrogenation (PDH) plant. The GHG accounting methodology has been applied either to some existing portions of the plant ('Base' cases), and Alternative design solutions. A technical description of the cases selected and studied is provided in the following.

3.1 Steam Boilers

Starting from the technical solution in place in the PDH Unit (Base Configuration), an alternative solution has been identified and studied. For both technical solutions ('Base' and 'Alternative'), the accounting of GHG emissions has been performed assuming that the solution was already implemented in the plant, and the plant in operation, thus neglecting the contribution, in terms of GHG emissions, of the construction operations required for its implementation.
In the Base case the High Pressure (HP) Steam Boiler System is composed of three separate HP-Steam boilers, each designed to generate and supply 140 t/h of HP steam. The three boilers use as fuel gas a mixture of process off-gas from PDH process unit and natural gas. In this configuration the thermal efficiency of each boiler is about 92.5%. Two out of three boilers (A and B) are equipped with forced draft (FD) fans driven by electric motors, while the FD fan of the third boiler (C) is driven by a steam turbine. In normal operation two boilers (B and C) are running at 100% capacity, while the thermal load of boiler A is adjusted to balance the overall steam demand. The power demand to each FD fan is equal to 565 kW. The overall electric power demand is thus 1130 kW and HP steam consumption is 10.9 t/h.
In the Alternative case, an optimized HP Steam Boiler System was evaluated. It consists of two separate HP steam boilers, each designed to supply 210 t/h of HP steam. For the analysis, the design thermal efficiency of each boiler was assumed equal to 93.5%. Performance data collected during plant operation confirms that thermal efficiency for boilers with capacity ranging from 200 t/h to 300 t/h is in the range 93% to 93.5%. Higher values are thus considered unrealistic. In this configuration it is assumed that one boiler is equipped with a FD fan driven by electric motor, while the FD fan of the second one is driven by a steam turbine. During normal condition one boiler is running at 100% capacity, while thermal load of the other boiler is adjusted to balance the overall steam demand. FD fan power demand is equal to 500 kW. Total electric power demand is 500 kW and HP steam consumption is 9.900 t/h.
The Scope 1 emissions arising from the combustion of fuel gas for steam production have been calculated assuming that all the carbon in the fuel gas is converted to CO_2. Scope 2 emissions (associated to the electrical energy required to move the fan) have been calculated considering the electricity emission factor (0.893 tCO_2/MWh) of the region where the plant is located.
The analyzed alternative configuration allows to reduce the fuel consumption by about 1.5%. This reduction, together with the reduction of the power required for the FD fan, turns into an overall saving in terms of CO_2 of about 2.4%. Due to the technological limitation on the boiler efficiency, it can be said that the alternative configuration does not produce a major benefit in terms of reduction of CO_2 emissions.
The assessment of the cost has been performed considering the replacement of three boilers with two boilers and by computing, for both the base case and the alternative solution, the related key quantities of piles and reinforced concrete structures required for their implementation.

The alternative solution, slightly environmentally better, has turned out to be also economically less expensive, with a cost saving of around 30%.

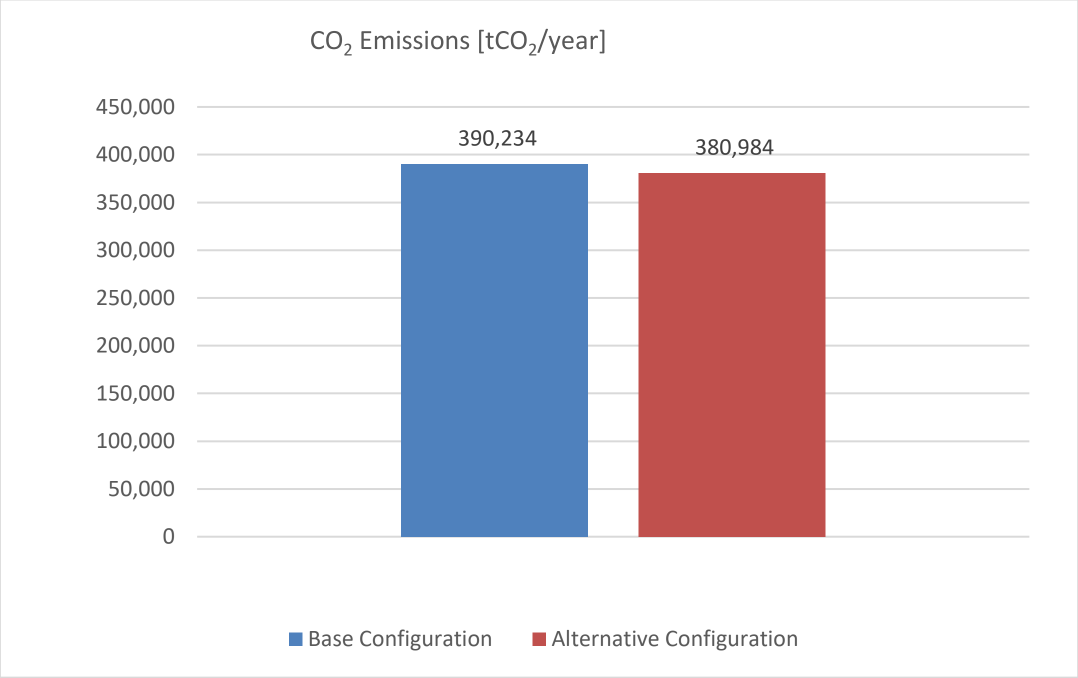

Figure 1. Comparison of CO_2 emissions from the base case and the alternative solutions

3.2 Steam Turbine vs Electrical Motor Compressor

The main compressors of PDH plant are the Reactor Effluent Compressor (located inside the Reaction Section) and the Heat Pump Compressor (located inside the Fractionation Section). In the base case these two compressors are driven by steam turbines. The alternative solution considers that the compressors are driven by electrical motors.

For the Base configuration, an energy balance on the steam turbine has been performed to evaluate the flowrate of fuel gas needed to produce the steam required to drive the compressor. The CO_2 produced in the combustion process has been calculated stoichiometrically assuming the complete combustion of carbon content present in the fuel gas. For this configuration emissions arise from a stationary combustion in the plant (Scope 1 emissions).

In the Alternative case, the compressors are not driven by steam turbines but by electrical motors. For this configuration, therefore, the CO_2 emissions associated to the compressors are accounted as Scope 2 emissions, since they are related to the consumption of electricity, produced outside the plant boundaries. For the evaluation of CO_2 emissions, the same electrical emission factor (0.893 $KgCO_2$ / kWh) as the previous case has been considered.

The Alternative configuration does not give advantages in terms of reduced CO_2 emissions. This result is because the consumptions, fuel for the base case, and electricity for the alternative configuration, are associated to different emission factors. The fuel emission factor is lower than the electricity emission factor in this case study. In the base configuration, in fact, the energy required for the compressors' operation is produced via the combustion of light, hydrogen-rich off-gas (H_2: 55% vol., CH_4: 31% vol), turning into a low equivalent emission factor; on the other hand for the alternative configuration, in the region (Russia) where the plant is located, the electrical energy imported from outside the plant to drive the compressors is mainly produced by coal combustion, turning into a high emission factor (0.893 tCO2/MWh).

The emission factor of the fuel depends only on the fuel composition, but not on the geographic location of the plant. Conversely, the electricity emissions factor is highly dependent on the geographic location of the plant, since it results from the fuels mix used for power generation in that region. The emission factors of electricity may vary greatly worldwide, ranging from 0.047 tCO_2/MWh in France to 0.476 tCO_2/MWh in United States to 0.961 $tonCO_2$/MWh in South Africa.

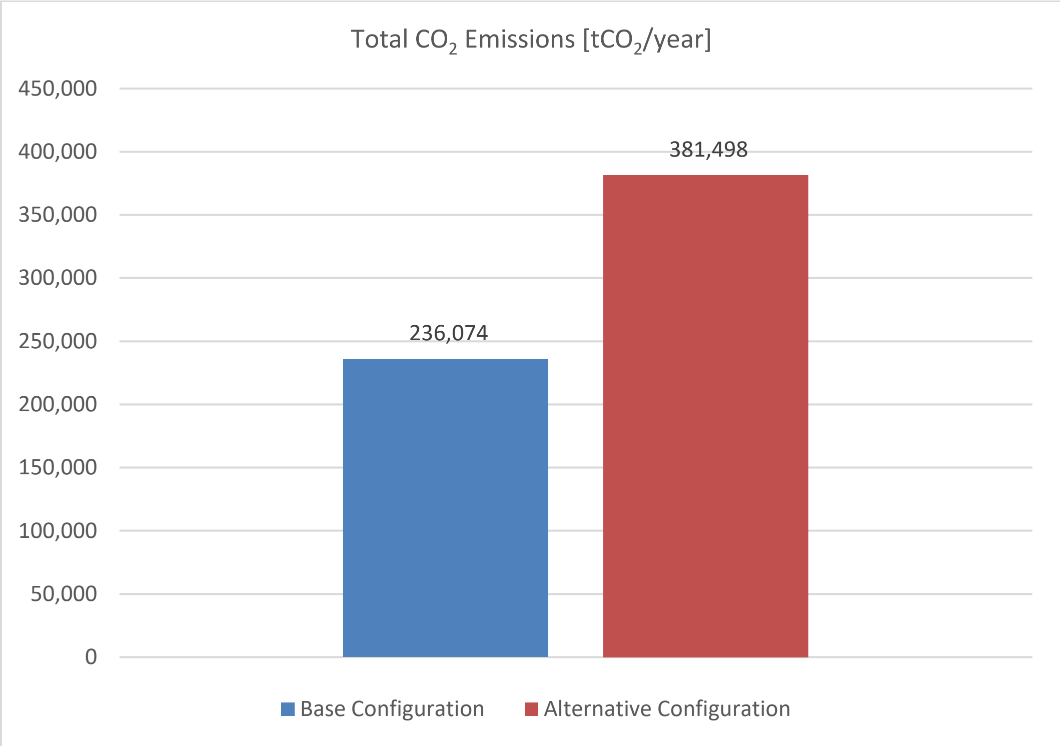

Figure 2. Comparison of CO_2 emissions from the analysed technological configurations

Starting from this consideration, it is therefore interesting to assess the impact, in terms of CO_2 emissions, of the alternative configuration in case the plant would be in a different geographical area, characterized by a different electrical emission factor. This analysis has been performed by considering the electricity emission factors of different geographical areas as reported in literature (Carbon Footprint, 2019), under the assumption that the energy required to drive the compressors would be the same, irrespective of the plant location. Results are reported in Table 2. The alternative configuration would allow to lower the emissions with respect to the base case in geographical areas where the electrical emission factor is lower than a threshold value of 0.5 tCO_2/MWh.

Table2: total CO_2 emissions as function of emission factor of different countries, considering the electrical energy consumption as in alternative case

Country	Electrical Emission Factor [tCO_2/MWh]	Carbon Footprint [tCO_2/y]
France	0.047	20,078
Germany	0.469	200,361
USA	0.4759	203,308
China	0.6236	266,407
Saudi Arabia	0.7176	306,565
Siberia	0.893	381,498
South Africa	0.9606	410,377

For the base case, the assessment of the costs has been performed considering the existing Reactor Effluent Compressor and Heat Pump Compressor, the associated condenser packages, and the steam generation system, resulting in a total estimated cost of about 60 M€. Such an estimate includes the cost of all the pieces of equipment, as well as the interconnecting piping, the instrumentation, the civil works (e.g.: foundations, etc.) that are required for the implementation of the base solution in the plant, ready for plant operation. In the

alternative case the steam turbine compressors have been replaced with units that are driven by electrical motors provided with variable speed drives (VSDs).
The definition of the alternative solution, required for this assessment, has considered:

i. the removal of reactor effluent compressor and heat pump compressor steam condenser package
ii. the removal of relevant condensate circuits
iii. the replacement of three steam generator packages with only one
iv. the consequent adjustment of civil and piping works
v. the addition of transformers, variable frequency drivers (VFDs)
vi. the replacement of switchgears
vii. the addition of Medium Voltage cables from substations to motors and of the related cable trays.

Eventually, the alternative solution has turned out to be less expensive than the base case, allowing a cost reduction of about 16%. The cost saving is attributable to the deletion of the equipment relevant to steam generation and condensation.

4. Conclusion

The present study provides an overview of the main implications of the application of the Equator Principles IV to a Project. It has been found out that the benefits are related to risk mitigation. A project that is compliant with the EP has greater chances to be financed since it is environmentally and socially sustainable.
This work evaluates the applicability of EP from the perspective of an EPC Contractor. Specifically, the analysis points out how an EPC Contractor could proactively act for demonstrating the compliance of a Project to the EP's with reference to the accounting of the greenhouse gases (GHGs) emissions. A methodology was developed to perform the accounting of greenhouse gases accounting, to fulfil the requirement of the climate change risk assessment, and the assessment of the cost of different alternative solutions. This methodology is flexible in terms of technological alternatives and can take into account the specific conditions of different geographical areas.
It can be used at various levels: first it demonstrates that the EPC Contractor can carry out Projects that comply with the application of the EP's; secondly, the Contractor demonstrates that is able to offer to its Clients a portfolio of different technological solutions, with the possibility to select those more environmentally sustainable.

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